Technical Note on CERES EBAF-Surface Ed2.8

Surface Downwelling Longwave Radiation (rlds)
Surface Upwelling Longwave Radiation (rlus)
Surface Downwelling Shortwave Radiation (rsds)
Surface Upwelling Shortwave Radiation (rsus)
Surface Downwelling Clear-Sky Shortwave Radiation (rsdscs)
Surface Upwelling Clear-Sky Shortwave Radiation (rsuscs)
Surface Downwelling Clear-Sky Longwave Radiation (rldscs)

1. Intent of This Document and Point of Contact (POC)

1a) This document is intended for users who wish to compare satellite-based estimate of surface radiative fluxes (irradiances) with climate model output in the context of the CMIP5/IPCC historical experiments. This document describes essential information about surface irradiances for this dataset needed for the comparison. References that provide more detailed information are provided at the end of this document.

This NASA dataset is provided as part of an experimental activity to increase the usability of NASA satellite observational data for the modeling and model analysis communities. This is not a standard NASA satellite instrument product, but does represent an effort on behalf of data experts to identify a product that is appropriate for routine model evaluation. The data may have been reprocessed, reformed, or created solely for comparisons with climate model output. Community feedback to improve and validate the dataset for modeling usage is appreciated. Email comments to HQ-CLIMATE-OBS@mail.nasa.gov.

Dataset File Name (as it appears on the ESGF):

rlds_CERES-EBAF_L3B_Ed2-8_200003-201311.nc
rlus_CERES-EBAF_L3B_Ed2-8_200003-201311.nc
rsds_CERES-EBAF_L3B_Ed2-8_200003-201311.nc
rsus_CERES-EBAF_L3B_Ed2-8_200003-201311.nc
rsdscs_CERES-EBAF_L3B_Ed2-8_200003-201311.nc
rsuscs_CERES-EBAF_L3B_Ed2-8_200003-201311.nc
rldscs_CERES-EBAF_L3B_Ed2-8_200003-201311.nc

1b) Technical point of contact for this dataset:

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2. Data Field Description

CF variable name, units:	Surface Downwelling Longwave Radiation (rlds) W m^{-2} Surface Upwelling Longwave Radiation (rlus) W m^{-2} Surface Downwelling Shortwave Radiation (rsds) W m^{-2} Surface Upwelling Shortwave Radiation (rsus) W m^{-2} Surface Downwelling Clear-Sky Shortwave Radiation (rsdscs) W m^{-2} Surface Upwelling Clear-Sky Shortwave Radiation (rsuscs) W m^{-2} Surface Downwelling Clear-Sky Longwave Radiation (rldscs) W m^{-2}
Spatial resolution:	1°×1° latitude by longitude
Temporal resolution and extent:	Monthly averaged from 03/2000 to 11/2013
Coverage	Global

3. Data Origin

Surface irradiances included in this dataset are from the CERES Energy Balanced and Filled (EBAF)-Surface Ed2.8 data product (Kato et al. 2013). They are computed using MODIS-derived cloud properties (Minnis et al. 2011) and atmospheric properties (temperature and humidity profiles) given by the Goddard Earth Observing System (GEOS-4 and 5) Data Assimilation System reanalysis (Bloom et al. 2005; Rienecker et al. 2008). To account for the diurnal cycle of cloud properties between 60°N and 60°S latitude, cloud fraction and cloud top height derived from five geostationary satellites (Minnis et al. 1995) are also used. Geostationary satellites are calibrated against MODIS (Doelling et al. 2013). Other inputs for irradiance computations include ozone amount (Yang et al. 2000), ocean spectral surface albedo from Jin et al. (2004), and broadband land surface albedos that are inferred from the clear-sky CERES measurements (Rutan et al. 2009). Because computed TOA irradiances do not necessarily agree with CERES-derived TOA irradiances, computed TOA irradiances are adjusted to be consistent with CERES-derived TOA outgoing shortwave radiation (rsut, rsutcs for clear-sky) and outgoing longwave radiation (rlut, rlutcs for clear-sky) from EBAF-TOA Ed2.8 (Loeb et al. 2009; Loeb et al. 2012). TOA irradiance adjustments are made by adjusting inputs (surface, atmospheric, and cloud properties). In the adjustment process, CALIPSO, CloudSat, and AIRS observations are used to constrain cloud and atmospheric properties (Kato et al. 2013).

4. Validation and Uncertainty Estimate

Regional monthly mean downward shortwave and longwave irradiances are compared with surface observations. A comparison of 10 years of coincident satellite-derived and surface-observed monthly mean irradiances for a number of sites shows that the bias (RMS difference) is 4.9 (12.5) W m^{-2} for downward shortwave and -2.0 (6.3) W m^{-2} for downward longwave over ocean and -1.7 (7.9) W m^{-2} for downward shortwave and 2.8 (8.3) W m^{-2} for downward longwave irradiances over land (Kato et al. 2013).

The estimated uncertainty in 1°×1° regional surface irradiances (Kato et al. 2012) is given in Table 1.

Table 1: Summary of uncertainties in the monthly 1°×1° gridded irradiance computed with satellite-derived cloud and aerosol properties in W m^{-2} (after Kato et al. 2012).

		Mean value	Estimated uncertainty
Downward longwave	Ocean+land[1]	345	14
	Ocean	354	12
	Land	329	17
Upward longwave	Ocean+Land[1]	398	15
	Ocean	402	13
	Land	394	19
Downward shortwave	Ocean+Land[1]	192	11
	Ocean	190	11
	Land	203	12
Upward shortwave[2]	Ocean+Land[1]	23	11
	Ocean	12	11
	Land	53	12

[1] Mean of ocean and land uncertainties
[2] Excludes polar regions where detecting sea ice or snow gives a large uncertainty in the upward shortwave irradiance.

5. Consideration for Model-Observation Comparisons

As mentioned earlier, clear-sky surface irradiances are constrained by CERES observations. As a result, the computed clear-sky irradiances are averaged using weighting by the clear-sky fraction. In contrast, climate models compute clear-sky irradiance by removing clouds. These two methods can produce significant differences in computed clear-sky irradiances. The clear-sky fraction-weighted surface downward longwave irradiance tends to be smaller than clear-sky surface downward longwave irradiance computed by removing clouds because observed clear-sky conditions happen when atmospheres tend to be drier (Sohn et al. 2010). Figures 1 and 2 show the difference of clear-sky irradiances computed with clouds removed and using clear-sky fraction weighting.

Other cautions in using this dataset for comparisons include:

- The source of temperature and humidity profiles for surface flux calculations changes from GEOS-4.1 to GEOS-5.2.0 starting in January 2008. The discontinuity in a time series of fluxes averaged over a relatively large scale (e.g. averaged over land or ocean) is mostly mitigated by corrections using GEOS-5.4.1 throughout the Ed2.8 period (see Section 4.8 of the EBAF-Surface Ed2.8 Data Quality Summary).
- There are regions where the surface flux adjustments are large, such as over the Andes, Tibet, and central eastern Africa. As a result, the deseasonalized anomalies over these regions can be noisy.
- The MODIS-derived aerosol optical thickness inputs change from Collection 4 to Collection 5. Collection 4 is used through the end of April 2006, and Collection 5 is used thereafter. As a result, a discontinuity and spurious trend can appear in the time series of regional clear-sky SW downward flux deseasonalized anomalies.

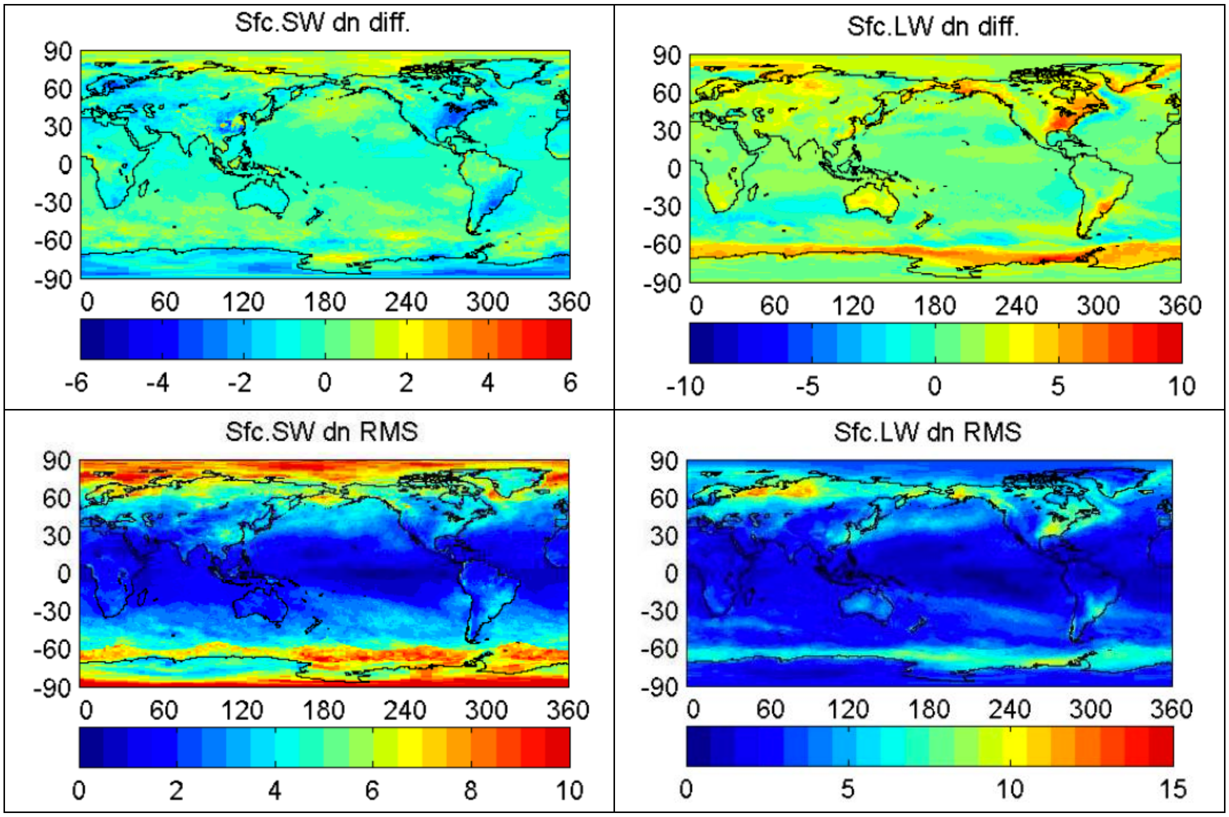

Figure 1. (top) Monthly mean difference and (bottom) RMS difference between cloud-removed and clear-sky fraction-weighted (left) surface downward shortwave fluxes and (right) surface downward longwave fluxes in W m^{-2}. The mean difference and RMS difference are computed using 10 years of monthly mean 1°×1° gridded fluxes from March 2000 through February 2010. The mean difference is defined as the clouds-removed minus clear-sky fraction-weighted fluxes.

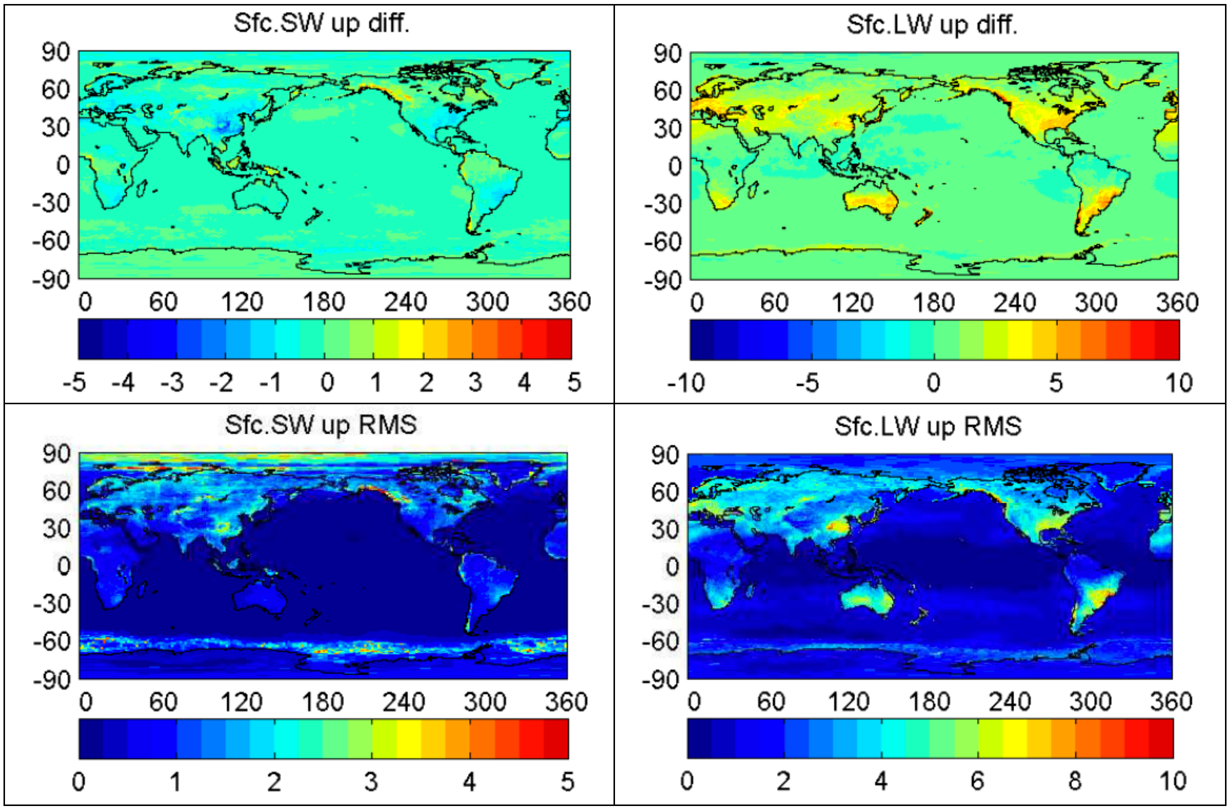

Figure 2. (top) Monthly mean difference and (bottom) RMS difference between cloud-removed and clear-sky fraction-weighted (left) surface upward shortwave fluxes and (right) surface upward longwave fluxes in W m^{-2}. The mean difference and RMS difference are computed using 10 years of monthly mean 1°×1° gridded fluxes from March 2000 through February 2010. The mean difference is defined as the clouds-removed minus clear-sky fraction-weighted fluxes.

6. CERES Instrument and Level 3 Products Overview

CERES instruments fly on the Terra (descending sun-synchronous orbit with an equator crossing time of 10:30 A.M. local time) and Aqua (ascending sun-synchronous orbit with an equator crossing time of 1:30 P.M. local time) satellites. Each CERES instrument measures filtered radiances in the shortwave (SW; wavelengths between 0.3 and 5 μm), total (TOT; wavelengths between 0.3 and 200 μm), and window (WN; wavelengths between 8 and 12 μm) regions. To correct for the imperfect spectral response of the instrument, the filtered radiances are converted to unfiltered reflected solar, unfiltered emitted terrestrial longwave (LW) and window (WN) radiances (Loeb et al. 2001). Since there is no LW channel on CERES, LW daytime radiances are determined from the difference between the TOT and SW channel radiances. Instantaneous top-of-atmosphere (TOA) irradiances are estimated from unfiltered radiances using empirical angular distribution models (ADMs; Loeb et al. 2003, 2005) for different scene types identified using retrievals from Moderate Resolution Imaging Spectrometer (MODIS) measurements (Minnis et al. 2011). Monthly mean irradiances are determined by spatially averaging the instantaneous values on a 1°×1° grid, temporally interpolating at 1-h increments for each hour of every month, and then averaging all hour boxes in a month. Level-3 processing is performed on a nested grid, which uses 1° equal-angle regions between 45°N and 45°S, and maintains area consistency at higher latitudes. The irradiances are then output to a complete 360x180 1°×1° grid created by replication.

7. References

The full version of CERES EBAF-Surface Ed2.8 is available from the following ordering site: http://ceres.larc.nasa.gov/order_data.php

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8. Revision History

Rev 0 – 14 Sep 2012– This is a new document/dataset.

Rev 1 – 28 Aug 2013 – Updated to Edition2.7 which includes using EBAF-TOA Edition2.7 for the constraint, correcting GEOS-4 and -5 boundary layer temperatures and humidities, correcting the 1º geolocation error, and applying a QC test. Updated the temporal extent to 09/2013 from 02/2010.

Rev 2 – 8 Aug 2014 – Updated to Edition2.8 which includes using EBAF-TOA Edition2.8 for the constraint and using a newer version of an AIRS product (AIRX3STM.006) for the initial correction of upper tropospheric relative humidity and to determine the uncertainties of GEOS temperature and humidity. In addition, the correction of the switch from GEOS-4 to GEOS-5.2 using GEOS-5.4.1 is extended to the entire globle. The correction was limited to 60°N to 60°S for Ed2.7. Updated the temporal extent to 11/2013.